

11 prb

PIEZOELECTRIC ACTUATOR

Prior Art

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5 The invention provides a piezoelectric actuator, e.g., for actuating a mechanical

6 component such as a valve or the like, according to the generic features of the

7 primary claim.

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9 It is generally known that, by utilizing the "piezoelectric effect", a piezoelectric

10 element can be built using a material having a suitable crystal structure. When an

11 external electrical voltage is applied, a mechanical reaction of the piezoelectric

12 element takes place that represents a push or a pull in a specifiable direction

13 depending on the crystal structure and the application site of the electrical

14 voltage.

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16 The piezoelectric actuators named previously are often used to position valves.

17 In this case it should be noted, among other things, that their lifting ability for

18 actuating a valve tappet, for example, is relatively small. On the other hand, the

19 different thermal expansion of the ceramic of the piezoelectric element and the

20 housing leads to problems; the piezoelectric element has a very low temperature

21 expansion and the housing, which is usually metallic, has a positive temperature

22 expansion, which can lead to a drifting of the position of the valve tappet without

23 control by the piezoelectric element.

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25 So far, such perturbing actions could only be diminished in the usual fashion by

26 using very expensive materials, such as invar, which have a negative

27 temperature expansion. Another method was to connect a material with high

28 temperature expansion in series with the piezoelectric element, which, however,

29 reduces the stiffness of the system and, therefore, the acutator force.

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## Advantages of the Invention

The piezoelectric actuator already explained hereinabove, which can be used to actuate a mechanical component, for example, advantageously comprises a piezoelectric element with which, according to the invention, a compensating element is arranged in parallel. It is particularly advantageous thereby that the piezoelectric element and the compensating element basically have the same temperature expansion coefficients, so that the temperature-induced expansions of the piezoelectric element and the compensating element—when the two elements are mechanically installed in suitable fashion—cancel each other out in the effective direction in such a fashion that an actuating element solidly connected to a pressing plate of the piezoelectric element remains in its position. It can therefore be achieved in simple fashion that a metallic housing, e.g., made of steel, is still used for the piezoelectric actuator, and the piezoelectric element can be fastened in the housing in such a fashion that the compensating element for temperature compensation is always solidly connected to the piezoelectric element. In an especially preferred exemplary embodiment of the invention, a heat transfer compound is located between the piezoelectric element and the compensating element, with which a good temperature compensation between the compensating element and the piezoelectric element can be produced.

According to the invention and in advantageous fashion, the piezoelectric element can be pretensioned in itself in simple fashion. The piezoelectric element is supported on one end against a fixed support plate that bears against a housing for the piezoelectric actuator via a spring. At the other end, the piezoelectric element is connected via a pressing plate to a pretensioning spring which, in turn, is held with its other end against the fixed support plate. The compensating element thereby lies basically parallel to the piezoelectric element and also bears against the fixed support plate at one end; at the other end, the compensating element solidly abuts the housing.

1 The pretensioning spring and the piezoelectric element can thereby be arranged  
2 in simple fashion in tandem, for example, whereby the movable end of the  
3 piezoelectric element can be connected to the pressing plate via a tightening  
4 strap. It is also possible, however, that the pretensioning spring and the  
5 piezoelectric element are situated parallel to each other, whereby, for instance,  
6 two symmetrically located zigzag springs can be located in the heat transfer  
7 compound as pretensioning springs that are also parallel to each other.

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9 The proposed interconnection of the piezoelectric element, the ceramic ring, and  
10 the pretensioning spring is solidly braced with the housing, whereby the  
11 pretensioning forces are much higher than the switching forces of the  
12 piezoelectric element, and the pretensioning spring makes a temperature  
13 compensation motion relative to the housing possible. The magnitude of the  
14 pretension can thereby be produced in simple fashion via a mounting nut. Even  
15 when the temperature expansion coefficient of the compensating element does  
16 not correspond to that of the piezoelectric element, the temperature  
17 compensation can be "tuned" via the length of the compensating element. In the  
18 exemplary embodiment, the support of the compensating element on the  
19 mounting nut represents the common zero point, which mounting nut is solidly  
20 connected to the housing.

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22 This and further features of preferred further developments of the invention arise  
23 out of the claims as well as the description and the drawings, whereby the  
24 individual features can be realized alone or in plurality in the form of  
25 subcombinations in the exemplary embodiment of the invention and in other  
26 fields, and they can represent advantageous and inherently patentable  
27 embodiments, for which protection is claimed here.

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## Drawing

Exemplary embodiments of the temperature-compensated piezoelectric actuator according to the invention, e.g., for the positioning of a valve, are explained using the drawing.

Figure 1 is a sectional view through a piezoelectric actuator held with a tightening strap with a compensating element and a pretensioning spring located behind it, and

Figure 2 is a sectional view through a piezoelectric actuator with a compensating element and pretensioning springs located parallel to each other.

## Description of the Exemplary Embodiments

Figure 1 shows a piezoelectric actuator that comprises a piezoelectric element 2 that is built in known fashion out of piezoelectric plies of a quartz material having a suitable crystal structure, so that, by utilizing the "piezoelectric effect", when an external electrical voltage is applied to electrodes not shown in this figure, a mechanical reaction of the piezoelectric actuator 1 takes place. In the piezoelectric actuator 1 according to Figure 1, the piezoelectric element 2 is made of ceramic and a compensating element 3 is also made of ceramic, but without a "piezoelectric effect".

The piezoelectric element 2 is surrounded by a tightening strap 4 that is welded to a pressing plate 5 at the top, which serves as the mount for a zigzag spring 6 as the tensioning spring. A base plate 11, with which the piezoelectric element 2 abuts, lies between the compensating element 3 which solidly bears against the housing 7 or a mounting nut on the other side, and a sleeve arrangement 8,

which, in turn, bears against a fixed support plate 9. The fixed support plate 9, in turn, is held against the housing 7 via a spring 10 for the compensating element 3. The pretensioning spring 6 is thereby held between the pressing plate 5 and the fixed support plate 9. In the exemplary embodiment, an actuation of the piezoelectric actuator 1 leads to an axial expansion of the piezoelectric element 2 and, therefore, to an axial motion of an actuating element not visible here.

A heat transfer compound 12 is applied between the piezoelectric element 2 and the compensating element 3, which makes an optimal temperature compensation of these two elements possible. Since the piezoelectric element 2 and the compensating element 3 basically have the same temperature expansion coefficients, the temperature-induced expansions of the piezoelectric element 2 and the compensating element 3 lead to a cancellation of the influences of both elements 2 and 3 in the effective direction with the proposed mechanical installation. The actuating element can therefore remain in its position.

A second exemplary embodiment of a piezoelectric actuator 20 is shown in Figure 2, whereby the equally-acting components are labelled with the same reference numerals as in Figure 1. In the arrangement according to Figure 2 as well, a piezoelectric element 21 and a compensating element 22 are produced out of a ceramic material with nearly identical temperature expansion coefficients. Zigzag springs 23, as pretensioning springs, arranged in parallel, and a heat transfer compound 12 are located here between the elements 21 and 22. In this exemplary embodiment as well, an actuation of the piezoelectric actuator 20 leads to an axial expansion of the piezoelectric element 21 and, therefore, to an axial motion of an actuating element—guided by a pressing plate 24 and not shown here—against the pretension of the pretensioning springs 23.

Since, in this case as well, the piezoelectric element 21 and the compensating element 22 basically have the same temperature expansion coefficients, the temperature-induced expansions of the piezoelectric element 21 and the

- 1 compensating element 22 lead to a cancellation of the influences of the two
- 2 elements 21 and 22 in the effective direction with the proposed mechanical
- 3 installation. The actuating element solidly connected to the pressing plate 24 of
- 4 the piezoelectric element 21 can therefore remain in its position.
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